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ART. XLIV.—*Terraces and Beaches about Lake Ontario*: by J. W. SPENCER, B.A.Sc., Ph.D., F.G.S., State University of Missouri, Columbia, Mo. (Late Vice-President of King's College, Windsor, Nova Scotia). With Plates VI and VII.

[Read before the Montreal Meeting of the American Association for the Advancement of Science.]

THE extreme western end of Lake Ontario is separated by Burlington Beach from the open waters of the lake, and forms Burlington Bay, having a length of about five miles, and a width of four miles at the eastern end, from which place it gradually narrows to less than half a mile, at the western end. This triangular bay is bounded on two sides by the Niagara escarpment rising from four to five hundred feet above the lake. At a short distance westward of the bay, the two faces of the escarpment suddenly approach to within about two miles of each other, and thence extend parallel to each other for several miles, having formed the boundaries of a grand ancient river valley, through which the waters of the Lake Erie basin flowed,—receiving, as a tributary, the Grand River, which drained the principal portion of the high lands of the peninsula of western Ontario,—in Pre-glacial times. This ancient valley is deeply filled with drift deposits, as described in a former paper read before the Association. Interglacial and modern streams have excavated deep valleys in the soft drift deposits producing a very broken country throughout the whole Dundas valley, as represented on Plate VI. Along the sides of the escarpments,

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and in some of the hillocks, fragments of ancient beaches and terraces remain.

The eastern portion of the Dundas valley is occupied by a marsh, which is separated from Burlington Bay by "Burlington Heights"—a ridge which rises abruptly from the waters (of the same level) on both sides, to a height of from 108 to 116 feet, with the breadth on the summit of only a few hundred feet. Burlington Beach, which separates the bay from the lake is the counterpart of the "Heights" and rises eight feet above the water. It is not usually more than a quarter of a mile wide. Burlington Bay is excavated out of Erie clay and is 78 feet at its greatest depth.

After this topographical description, let us now consider the elevation of the beaches and terraces, and their composition. (See Plates VI and VII.)

1. The lowest beach is that forming the present lake margin and rising to a height of eight or ten feet above its surface, of which Burlington Beach is a portion. It is composed wholly of sand and pebbles (mostly flattened) derived from the ruins of various rocks of the Hudson River formation, with a few small crystalline pebbles. The pebbles are often full of characteristic Hudson River fossils. Sometimes the rounded slabs measure more than a foot in length, though usually much less. At the western end of the lake the present beach does not contain any pebbles of the Niagara formation. The nearest exposures of the component rocks are more than twenty miles away to the northward.

2. The next terrace is 70 (to 80) feet above the lake, and consists of sand,—or, in the Dundas valley, where it forms a conspicuous flat terrace, it is composed of thin-bedded loose arenaceous clay, with some fine gravel along the margin. This terrace in the Dundas valley is the remnant of the deposits of Saugeen clay.

3. The most conspicuous of all the terraces is that at 116 feet above the lake, of which "Burlington Heights" is a portion. Its composition is precisely of the nature of Burlington Beach, and on a succeeding page, the structure will be more fully noticed in studying its origin, along with that of Burlington Beach.

4. The upper portion of an isolated conical hill, rising to 180 feet on the southern side of Dundas, is composed of stratified fine gravel, probably of the Hudson River formation, but with large stones and semi-angular slabs (sometimes a foot and a half long) composed of Niagara dolomites and other rocks of that formation.

5. On the northern side of the town of Dundas there is an old beach with the sand and fine gravel exposed from 224 to 261 feet above the lake.

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6. Higher up, on the side of the escarpment north of the town (at the mouth of Glen Spencer), and not distant from the last beach, there are still the fragmentary remains of stratified gravel and sand rising to 335 feet above the lake. This deposit probably reached higher at a former time, but has been removed from the steep side of the so-called "mountain." It is composed of a mixture of Niagara and Hudson River pebbles and sand, with a few crystalline pebbles. Farther up the Dundas valley and near Ancaster, this same beach is represented in fragments on some of the hills. But there they are composed more largely of fine materials of Hudson River age, with only slabs of Niagara rocks (being farther removed from the escarpment).

7. Westward of Ancaster village, and near the watershed between the present Dundas valley (at an estimated height of 440 feet above the lake), there is another beach composed largely of Hudson River pebbles, and showing much oblique bedding, dipping at 23 degrees to the southeastward. Farther southeastward we again find an old beach at the same elevation adjacent to the Grand River.

8. On top of the Niagara escarpment, just north of the village of Waterdown, there is a beach of very fine gravel at a height of about 500 feet above Lake Ontario.

From the study of the beaches in the Dundas valley there appears to have been simply a gradual recession of the water with comparatively few sudden changes of level—the most sudden being between the deposit of the terrace at 116 feet above, and that at the present lake level.

Between Toronto and Lake Simcoe, Mr. Thomas Roy, in 1837, measured beaches at 110, 210, 282, 310, 346, 402, 422, 502, 558, 626, 682, 734, 764 feet respectively above Lake Ontario. In addition to these gravel beaches, others at 600 feet, and, on descending toward Georgian Bay (along the Northern Railway) at 520, 388 and 354 feet, have been measured. Along the Toronto, Grey and Bruce Railway, which extends in a direction north of west from Toronto to the highest portions of the peninsula of Ontario, and crossing the "Artemesia Gravel" ridges, there are a number of conspicuous beds of sand and gravel, which follow contour lines more or less closely. The elevations of some of the most conspicuous of these deposits were furnished by the kindness of Edmund Wragge, Esq., Chief Engineer of the Railway. They are at 160, 280, 370, 710, 990, 1120, 1340 feet respectively above Lake Ontario. After passing the summit of the road, at 1462 feet above the lake, there are extensive gravel beds at 1310 feet, and from 1000 to 697 feet above the same datum, along the main line, and along the western branch at 1299, 1130, 1050, 870, 850

and 830 feet above Lake Ontario. Near Owen Sound there are others at 546, 496 and 466 feet above Lake Ontario.

Along the Great Western Railway, adjacent to the valley of St. David's (near the Niagara River), there are stratified sands and gravels (of Hudson River epoch) from 383 to 250 feet above the lake.

In New York State, eastward of Lockport, the lake ridges rise from 158 to 190 feet above the lake (Hall). On the southeastern margin of the lake-basin there are old beaches at 400 feet, and at the north end of Skaneateles Lake, at about 625 feet above Lake Ontario, there are still others. But the collected records of the New York terraces are too fragmentary for general comparison.

In the appended table the reader will be immediately impressed with the relationship existing between the beaches at the various elevations which surround the lake, and the continuity of the slow recession of the waters. The higher beaches, of course, refer to the time when the waters of all the Great Lakes were united in one body. In Michigan there are beaches at 1350 feet above Lake Ontario. Near Petits Écarts, Lake Superior, beaches at 398, 408, 458, 592, 627, 635 and 699 feet above Lake Ontario were measured by the Geological Survey of Canada.

Again to the southwestward of Lake Erie, Messrs. Gilbert and Winchell measured beaches or ridges at 65-90, 165, 195, 220, 350-408, 386-490 feet above Lake Erie.

The belt of the *Artemesia* gravel may approximately be represented by the contour line of 1250 feet above the sea, but extending southward of this line to somewhat beyond the contour of 950 feet. It is thus described by Dr. Bell: "This great belt of gravel has a general parallelism with the Niagara escarpment and follows the highest ground of the peninsula. The materials composing it consist principally of the ruins of the Guelph formation, on which the greater part lies, except toward the southern extremity, where the Niagara formation is largely represented. Pebbles of Laurentian and Huronian rocks are everywhere mixed with the others, and sometimes form a considerable proportion, while rounded fragments from the harder beds of the Hudson River formation occur locally in some abundance." (These last rocks are derived from lower levels.) "The gravel is all well rounded and generally coarse. It often constitutes what might properly be called 'cobble stones,' being loose and free from any admixture of clay; and it is distinctly stratified. Well worn boulders of Guelph, Laurentian and Huronian rocks are disseminated through the whole mass." In a few places this gravel overlies blue Erie clay. From the eastern side of the *Artemesia* gravel ridges, there extends a long comparatively narrow ridge for about 100 miles

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to near the Trent River, known as "Oak Ridge." Its most conspicuous portion may be represented by the contour line of 650 feet above Lake Ontario, although the highest portion rises to 893 feet. Its height is from 200 to 300 feet above the broad

TABLE OF ELEVATIONS OF TERRACES, BEACHES AND RIDGES.  
Elevations in feet above Mean Tide.

At Western end of Lake Ontario (Spencer).	Between Toronto and Lake Simcoe (Roy).	Along Northern Railway.	Along Toronto, Grey & Bruce Railway (Wragge).	Near Owen Sound (Bell).	Petita Escrita, Lake Superior (Geology of Canada).	In New York State.	At Western end of Lake Erie (Geology of Ohio).	Along the St. Lawrence (Dawson).
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\* Summit of land.

† On Highlands of Michigan.

‡ Along Toronto, Grey & Bruce Railway.

§ Along W., G. & B. Railway.

|| Beach, also of the elevation on Mackinac Island.

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\*\* Along Whitby Br. of Midland Railway.

†† Along Midland Railway.



rock-bottomed trough which extends from the Georgian Bay to the eastern portion of Lake Ontario. The descending portion of this ridge may be represented by a contour of 250 feet above Lake Ontario, to which it approaches at Scarboro Heights. The composition of the whole thickness to lake level (more than 300 feet) is here shown and consists mostly of stratified sand and clay, with two intercalated beds of boulder-bearing clay.

There is a resemblance between the *Artemesia* ridges and the so-called Kettle Moraines of Wisconsin, Coteau des Prairies and Coteau de Missouri. There is a general parallelism between these ridges. The *Artemesia* gravel reaches 1700 feet above the sea—a height as great as portions of Coteau des Prairies.

From the structure of both the "*Artemesia* Gravel" and "Oak Ridge," there is no evidence of their being of morainic character. The deposits of the *Artemesia* gravel are simply around the high rocky floor of this portion of the country, and mark the recession of the waters in more or less perfect contour lines, with most of the material of local origin.

Whatever barriers may have separated the lake region from the sea, there seems no doubt that the whole area was submerged beneath the sea level to at least 1700 feet, for no glacial lake could account for the high level beaches. From the character of the deposits there appears to have been but little floating ice—perhaps not much more than the ice-fringes of the present day. The highlands south of the lakes do not rise to any such height as to permit a small amount of floating ice to barricade them to the height of several hundred feet.

As the continent was rising, the waters of this inland lake had many channels communicating with the exterior sea, across Ohio and New York, besides that by way of the St. Lawrence. However, local oscillations probably played an important part, but to what extent cannot yet be well determined.

Below 1200 feet above sea level of to-day, the principal old outlets are by the valley of Cayuga Lake, at 1015 feet; by Seneca Lake valley, at 865 feet; by the Mohawk River, at 434 feet, and by the present St. Lawrence River, at 247 feet above mean tide. In Ohio, Dr. Newberry enumerates various other outlets at 936, 968, 909, 910 and 940 feet above present ocean level.

There is a remarkable connection between these old outlets and the beaches which rise a few feet above them, in that they are conspicuous and are most widespread.

Many of the transported bowlders of crystalline rocks may have been carried by the floating ice of the great lake of the time; but the explanation of the Hudson River pebbles and

slabs, which are observed in the old beaches, higher than these original sources, can be best accounted for by the theory that they were carried upward by the coast-ice during the time when the continent was undergoing subsidence, and were rearranged by the waves and shore ice of a later period.

Let us now return to the lower water margins of Lake Ontario, represented by "Burlington Heights" and "Burlington Beach," which are almost wholly composed of Hudson River pebbles. The former of these ridges is 116 feet and the latter eight feet above the lake. Both of these beaches, of the same materials, skirt much of the western shores of Lake Ontario.

Their component pebbles and sand appear to have been entirely transported by the action of shore-ice and waves. At the commencement of the deposit of the beach at 116 feet above the present water, the Dundas valley formed one continuous basin with the lake bed. But at that time, as now, only the extensions of Lake Ontario forming bays were frozen over in winter. The Dundas valley, being a confined arm, was frozen over, and the pebble-laden ice, from the more exposed coast, was drifted by the winds and currents, and packed across the front of the ice-sheet, covering the waters in this arm of the lake, at 116 feet above their present level; and with annual dissolution of the ice, the small amounts of material transported during the winters began to deposit the barrier, which was in course of time destined to produce "Burlington Heights"—the beach of that day. The location of the "Heights" was in no way produced by the unimportant streams flowing down the Dundas valley, as is apparent, for the Pre-glacial and Inter-glacial drainage of the western peninsula of Ontario was turned into Lake Erie before the Terrace Epoch. The false and inclined bedding of the "Heights" is always toward the lake (the material sometimes consisting of fine beds of sand, and sometimes of clean large gravel) showing that the stratifying forces proceeded from the side of the lake. In addition to the transportation of the material by ice, the action of the waves in no small degree assisted in the production of this old beach.

The present "Burlington Beach" is simply a reproduction of the "Heights" since the time when the lake receded to its present level. Burlington Bay is frozen over every winter, but the lake is seldom frozen to a greater extent than enough to produce fringes. Yearly much ice shod with pebbles is drifted against the western shores of the lake by the action of storms and waves. In this way much of the western end of the lake, although almost against the foot of the Niagara escarpment, has had its shores made up of pebbles and sands of Hudson River formation. A small portion of the shore material may have been derived from the ruin of former beaches at higher levels.

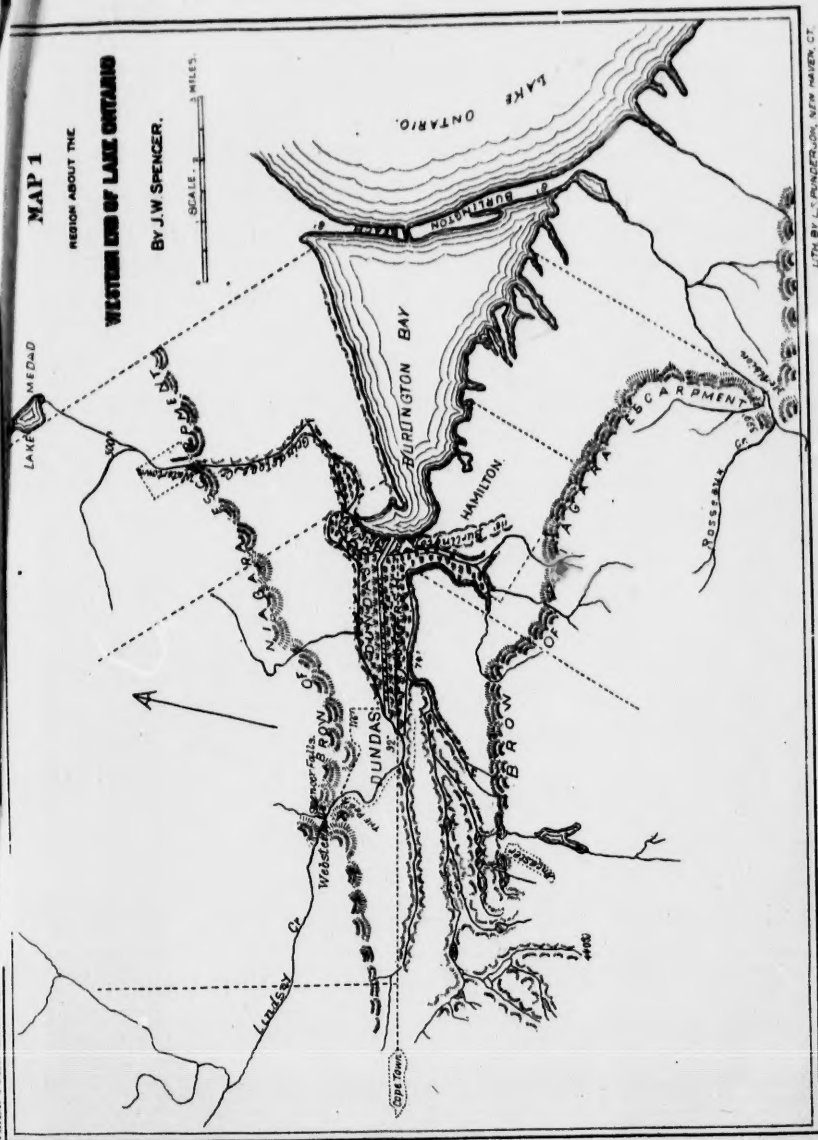


In conclusion, it may be said that the country covered with "Artemesia Gravel" gives no evidence of any morainic origin of the deposits, but rising from the great subsidence of the Terrace Epoch, it was first an exposed island, and afterward it formed a more extended margin, as the waters were contracting to within their present basins.

When the ancient beaches and terraces in the whole region of the Great Lakes shall have been carefully measured and studied with reference to their original extension, then there may be some accurate data for the determination of the relative amounts of local and general oscillations of the continent, for we see that the above fragmentary lists of elevations show a close relation between the different beaches, which would doubtless be further borne out, were the measurements more complete, and made with a view of arriving at true scientific results.

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LITH BY L. S. BRIDGERSON, NEW HAVEN, CT.



Am. Jour. Sci. Vol. 11



## MAP 2

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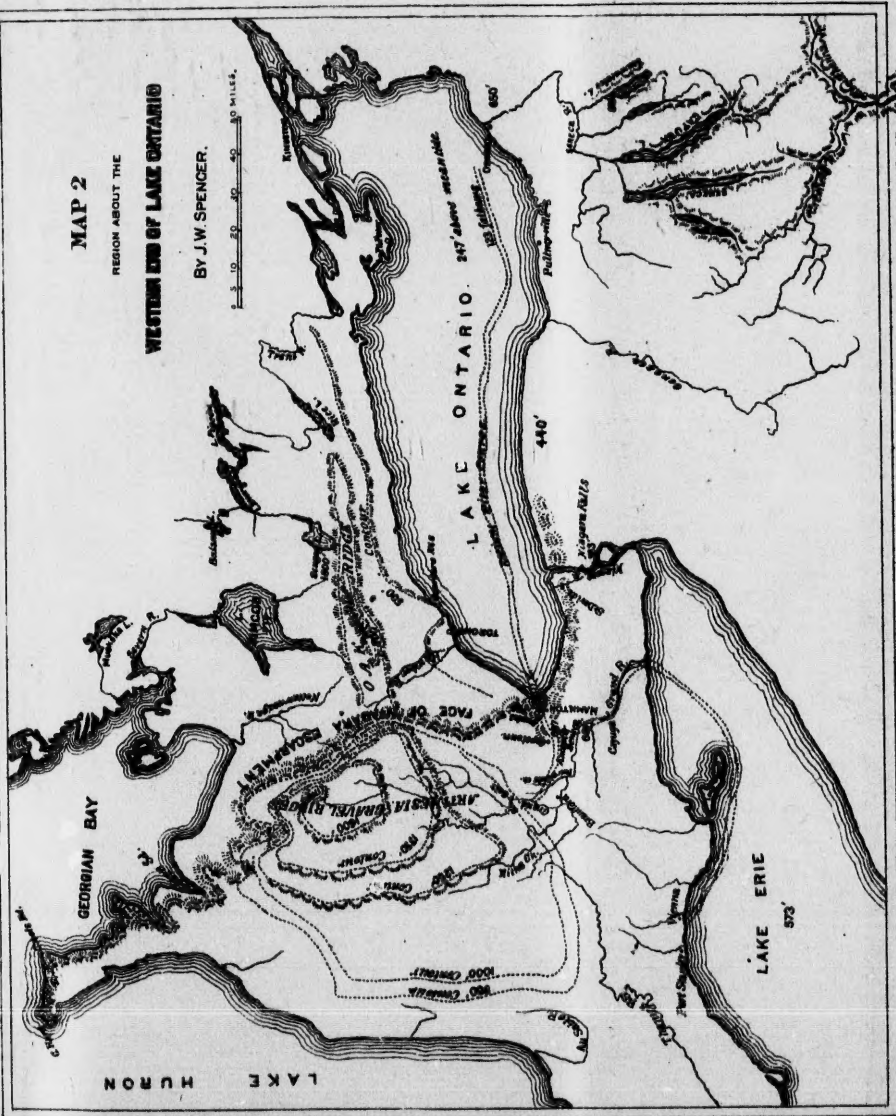
# MAP 2

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## WESTERN END OF LAKE ONTARIO

BY J.W. SPENCER.

0 5 10 20 30 MILES.



PHOTOGRAPH BY L.S. RINDERS, NEW HAVEN, CT.